Campbell 2ed
(1-18)

Z:

1852

21 Tavistock Sqre
J R Gladstone
Monday. about 12

[illegible]

2.

ON THE
INFLUENCE OF THE SOLAR RADIATIONS
ON THE
VITAL POWERS OF PLANTS
GROWING UNDER
DIFFERENT ATMOSPHERIC CONDITIONS.

By J. H. GLADSTONE, Ph.D.

[*From the* Report of the British Association for the Advancement of Science *for* 1852.]

LONDON:
TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

On the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric conditions. By J. H. GLADSTONE, *Ph.D.*

THERE are few subjects of experimental research in which such opposite statements have been made as on the mutual action of the atmosphere and the vegetable kingdom; even the apparently simple question as to whether plants increase or diminish the amount of oxygen in the air was long a matter of dispute. This arose partly from defective modes of analysing gases; partly from experiments upon plants being made under circumstances very unfavourable to their healthy development; and partly also from variations in light having a great influence in modifying the functions of the vegetable world. The history of these discussions, in which many of the greatest philosophers of the day took part, is too long and too well known to need further notice here. When it was fully conceded that carbonic acid really is decomposed by the plant, it was natural enough that those who observed the wonderful powers of the chemical rays of the solar spectrum in reducing salts of silver and other substances, should refer the chemical changes taking place within the vegetable tissues to the same occult agency. But Dr. Daubeny, in an admirable investigation, published in the Philosophical Transactions for the year 1836, has shown by indisputable evidence that it is the luminous, and not the chemical or the calorific rays, which cause the decomposition of carbonic acid with emission of oxygen from the leaves, the formation of chlorophyl, the irritability of the *Mimosa*, the evolution of water, and indirectly at least the absorption of it by the roots. The colours of flowers are supposed by this author to depend also on the luminous rays; sunshine was found to act far more energetically than diffused daylight, while no colouring effects were observed to be produced by any artificial illumination, not even by that afforded by incandescent lime.

That portion of the inquiry requested by the British Association which devolved upon me, embraced a question not included in the investigations of the Oxford Professor, nor in those of any other experimentalist, as far as I am aware: I refer to the influence of various atmospheric conditions in conjunction with light. This circumstance necessitated the employment of closed vessels under which the plants should be grown; and glass, from its transparency, was not only the best but almost the sole article which could be employed. Bell-shaped glasses were accordingly procured; and they were made of various colours, in order that the different properties of the spectrum might be to a considerable extent separated.

The blue glasses mentioned in this paper had each a capacity of about 690 cubic inches. A smaller bell-glass of 172 inches capacity was also employed in an experiment not described on the present occasion. The yellow glasses had a capacity of 650 cubic inches; the red of 558; and those made of colourless glass of 740 cubic inches. The darkened glasses mentioned below were made by partially covering bell-jars with brown paper, thus excluding the light except such as passed through about one-eighth of the surface of the glass, and that on the side turned away from the window. Their cubic contents were 500 inches. Small colourless and yellow glasses were also procured, each having a capacity of 177 cubic inches.

The blue glass employed is of so intense a colour, that it cuts off by far the greater portion of the luminous rays, but photographic paper showed that it admits the chemical rays freely; it may also be considered as interfering much with the transmission of heat. The red glass, on the contrary, freely admits the calorific influence, but stops the chemical, whilst, like the blue, it diminishes greatly the luminous. The yellow again scarcely decreases the illuminating power of light, but almost destroys its chemical action.

The place in which the experiments here described were conducted, was a room in a dwelling-house at Stockwell, in the neighbourhood of London. The glasses stood on a table close by the window, which had a S.S.E. aspect. No fire was ever lighted in the room, but it must have been a little warmer than the external atmosphere in the winter time on account of the vicinity of heated apartments.

As preliminary experiments, merely the effect of these coloured glasses in accelerating or retarding the growth of various kinds of plants was tried.

Hyacinths were chosen as samples of bulbous-rooted plants. They were all of the same description, purple in colour, as nearly as possible of the same size, healthy, and beginning to put forth a plumule and radicles. They were weighed, placed on the top of colourless glasses containing sufficient pure water just to touch the rootlets, and then covered with the large glass shades. The experiments were started on Nov. 13th. In order to change the air, the shades were lifted off for a minute or two about every second night. Each plant grew healthily and flowered; yet some differences were observed of a character which might fairly be attributed to the quality of the light. First, as to the rootlets. Under the colourless glass they grew abundantly; under the blue glass they also grew abundantly and more rapidly; under the red glass scarcely any rootlets were produced, and what there were never attained any considerable length; while under the yellow glass they were few in number, but long. Secondly, as to the leaves and flower-stalk. Under the colourless glass they were put forth in process of time and grew healthily. No difference was noticeable under the blue; under the red long spreading leaves were put forth, that bent towards the light in a very marked manner, and the plant had an unhealthy appearance; while under the yellow glass short sturdy leaves and flower-stalks were produced.

As to the flower itself, it began to open at about the same period in each instance, namely,—

Under colourless glass,	on	Feb. 11th,	or after	90	days.
Under blue	„	„	10th,	„	89	„
Under red	„	„	8th,	„	87	„
Under yellow	„	„	10th,	„	89	„

There was no observable difference in the colour of the four flowers, notwithstanding the variety of tint under which they had been formed. The flower under the red glass was long and thin. Latterly they all suffered for want of room.

On April 16th all the plants were removed from the water into which their rootlets dipped, dried in the air, and weighed.

		Primary weight of bulb.	Weight of fully developed plant.
Under colourless	glass	1305 grs.	2118 grs.
Under blue	„	1328 „	2026 „
Under red	„	1135 „	1386 „
Under yellow	„	1299 „	1704 „

showing an increase of—

Under colourless glass, as 1000 : 1623
Under blue „ 1000 : 1525
Under red „ 1000 : 1221
Under yellow „ 1000 : 1312

The greatest growth therefore was in the plant exposed to all the influences of the solar ray.

Cereals were also grown under the various glasses, a comparative experiment being made under a darkened shade. Access of air was permitted to the plants by the glasses being placed upon boards which were perforated with holes close together, and were raised about one-third of an inch from the table. No direct rays of light could enter, especially as the space under the boards was blocked up on the side nearest the window, and any diffused light finding access by the perforations had to pass through several folds of tarlatane of the same colour as the glass shade itself.

On Sept. 12th three grains of white wheat, sown in garden mould, to which a little stable manure was added, were placed under the various glasses. The wheat began to grow in a few days in each instance, one seed only under the red glass proving unproductive. They were watered as occasion required. In a week or two the plants under the darkened shades attained a considerable height, turning in a very marked manner to that part where most light entered. No secondary leaves ever appeared, but each plant consisted of two long white leaves of about 9 inches in length, so thin and flaccid that they were unable to support themselves; and after thirty days they drooped entirely and became mouldy. The corn-plants under the other glasses grew more slowly, but put forth many leaves, attained a height of 10 or 12 inches, and remained healthy throughout the winter and spring. Those under the yellow glass were the most sturdy in their growth; and those under the blue alone appeared thin and unhealthy.

Mallow-seeds (*Malope trifida*) were sown in garden mould, and placed under the various glasses near the commencement of September, the arrangements being the same as in the preceding experiment. They began to grow after the lapse of a few weeks, first under the colourless glass, then under the blue, and afterwards under the red, yellow, and darkened glasses at about the same time, October 8th. Thin etiolated stalks, with only the first pair of leaves, and those badly developed, about 2 inches in length, were all that was produced under the darkened shade. In about a fortnight they died; and in the middle of March some other seeds sprouted in a precisely similar manner. The mallows under the other glasses grew more healthily and survived much longer, but in no instance did they arrive at maturity: the best plant was one that grew under the yellow light; it had sprouted in the early part of January and put forth many leaves, reaching the height of 5 inches. They grew worst perhaps under the blue glass. A self-sown *Stellaria* grew luxuriantly along with the mallows under the red, and a grass-plant under the yellow shade.

In a paper read by my brother and myself before the Association last year, and published in the Philosophical Magazine for September 1851, we remarked that plants kept in an unchanged atmosphere appear to enter into a sort of lethargic condition. An experiment was instituted for the purpose of ascertaining whether the alteration in light produced by coloured media made any marked variation in this matter; and as the pansy and *Poa annua* were the plants generally experimented on in our previous investigation, they were employed here likewise. Six pansies newly struck, which had taken good root and were vigorous, were planted in six flower-pots containing good garden mould; and with each was also placed a grass-plant in flower. They were all set in trays filled with water to the depth of an inch, or thereabouts; five were covered with the different descriptions of glass shades dipping into the water, so as to cut off all communication between the external and internal atmospheres; while one was freely exposed to all the changes of the surrounding air. The experiment was commenced on October 17th, and access of air was never permitted to the covered plants. The results under the glasses were very various, but how far they depended upon the character of the light or upon the peculiar atmospheric condition, could not be determined with any accuracy. One thing however was clear, that the plants survived much longer for being in an unchanged atmosphere. The pansy that was not covered by any shade was attacked with aphides eight weeks after the commencement of the experiment, and although these were washed off, it drooped before the end of December. The *Poa* also scarcely survived the winter. Under the colourless glass the plants remained healthy much longer; the pansy was attacked by the forementioned insects at the commencement of December, but although it was necessarily impossible to remove the aphides without disarranging the experiment, the plant lived till March. The grass-plant grew very luxuriantly. A curious phænomenon was observed. As the air within the glass shade was perfectly still, the ripe seeds of the *Poa* did not fall from the flower-stalk, and through the dampness of the atmosphere many of them which rested against the sides of the glass germinated and shot forth leaves, in some instances 3·5 inches long, and radicles of 1 inch in length. Under the blue shade the plants grew very tall. No aphides appeared, but mouldiness was observed. In March both plants were straggling and unhealthy; the grass-seeds never germinated; and any portion that died quickly suffered decomposition. The plants exposed to the red light were healthy at first, and the grass grew luxuriantly; but aphides appeared on the pansy in the middle of December, and at the commencement of the succeeding month it became sickly and drooped. The grass-plant also lost its healthy appearance during the spring: some of its seeds germinated. Under the yellow glass neither of the plants increased in size at first, but in the spring they grew, the grass attaining a very great length; they maintained a strong and healthy appearance; no insects showed themselves on the pansy, and the grass-seeds gave little indications of germinating. Some changes in the colour of the pansy's leaves were observed to take place, but the grass remained of its proper green tint. The plants under the darkened shade soon became sickly. On December 11th the grass was found to be dead; the pansy had grown tall, and turned decidedly towards the least darkened part of the shade; it was mouldy and ill-favoured, and on January 6th it drooped.

Researches connected with the growth of plants must necessarily stretch over a considerable space of time. My object in detailing these experiments now is not to draw any general conclusions from them; I regard them as far too few and uncertain for that; but offer them to the Association as a sample of my preliminary attempts in this inquiry,—attempts which may indicate a line of fruitful investigation in future seasons.